

Composition and ecological distribution of forest soil animal in Confucian graveyard of Qufu

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Abstract: Soil animal communities of Secondary forest, *Platycladus* forest and *Quercus acutissima* forest in Confucian graveyard of Qufu were investigated. 3583 specimens were collected, belonging separately to 5 Phyla, 11 Classes and 23 Orders. Two dominant groups and 9 common groups account for 94.45% of the total numbers. The soil animals in these three forest habitats differ in composition, ecological distribution and important indices. The dominant groups of soil animals in the three forests were the same, but other groups differ more greatly. Diversity index (H') and evenness index (E) of soil animal in Secondary forest are the highest, and yet dominance index (C) in *Quercus acutissima* forest is the highest. Most soil animals in each forest habitats congregate to the surface soil layer. Their sorts and individual numbers are all layer I > II > III. It is very similar for composition of soil animals in the three forests.

Keywords: Forest soil animal, Species composition and distribution, Confucian graveyard of Qufu

Introduction

Actions of soil animals such as taking food, moving and perch etc., strengthen forest litter, other biotic remains and liquid and solid pollutants to decompose and transform, quicken material circulation and energy flow in forest ecosystem, which are profitable to growth and refreshment of forest plant (Zhang 1980; Cui 1985). To supervise and survey the species and numbers of forest soil animals can indicate the change of forest ecological environment, meaning for protecting forest and maintaining balance of forest ecosystem. Confucian graveyard of Qufu, a special graveyard of Confucian family, was built 2400 years ago. Up to now, a great area of forest vegetation has been established and there are many ancient priceless trees in it. Lush forest trees become mixed form with many tombstone and stone sculpture. For these reasons, Confucian graveyard of Qufu became a sacred place of tourism and was elected to the World Natural and Cultural Remains by the United Nations Education and Science and Culture Organization in 1994. The authors made an initial investigation on the forest soil animals in Confucian graveyard of Qufu during 1995 to 1996 to find out the composition and ecological distribution of forest soil animals. The purpose of this study was to provide basic information for further study and protection of Confucian graveyard and its forest ecosystem and to maintain its ecological balance.

Study area and methods

The study area, Confucian graveyard of Qufu (36°36' N, 117°42' E), is located in the northern part of Qufu town, Shangdong Province. The site covers a total area of 185 hm², with 150 hm² of forest in it. The local climate belongs to the south warm temperate zone. Annual average precipitation is 600.3 mm, mostly distributed in June to August. Annual averages temperature is 13.6°C. Soil type is damp brown soil. The vegetation belongs to deciduous broad-leaved forest and coniferous forest due to the long-time influence by human and nature.

The forests in investigated site were divided into three types: Secondary forest (S), *Platycladus* forest (P) and *Quercus acutissima* forest (Q). Soil samples were collected randomly. The sampling sizes were 50 cm × 50 cm × 15 cm for large-sized soil animals, 100 cm × 100 cm × 100 cm for mid-small sized soil animals and 25 cm × 25 cm × 25 cm for Feuchtluftiere. Soil samples were collected in 0-5 cm (I), 5-10 cm (II) and 10-15 cm (III) layers. The specimens of soil animals were separated and extracted from the soil samples by hand-picking method (for large sized soil animals), Tullgren method (for mid-small sized soil animals) and Baermann method (for Feuchtluftiere). The specimens were identified according to J.AOKI and parts of entomological classification handbook (Yin 1992; Zhang 1993; Zhong 1985; Jin 1985).

Results and analysis

Totally, 3583 soil animal specimens were collected (not including protozoa) from the study area. They

belongs to 5 Phylums, 11 Classes and 23 Orders, of which, Mematoda and Acarina are dominant groups and 9 groups such as Collembola, Hymenoptera, Coleoptera etc. are common ones (Table 1). The individual numbers of dominant and common group

account for 94.45% of the total numbers of soil animal acquired, making up the main part of forest soil animal community in Confucian graveyard. 14 rare groups and one extreme rare group only account for 5.3% of the total numbers of soil animal.

Table 1. Composition and quantity indices of soil animals in three forest habitats in Confucian graveyard

| Species | Secondary forest | | Platycladus forest | | Quercus acutissima forest | | Total number | Mean frequency (%) | Abundance |
|-------------------------|------------------|-------|--------------------|-------|---------------------------|-------|--------------|--------------------|------------------|
| | Number | % | Number | % | Number | % | | | |
| Acarina | 232 | 21.54 | 221 | 16.26 | 235 | 20.49 | 688 | 19.20 | +++ ^① |
| Nematoda | 344 | 31.94 | 683 | 50.26 | 594 | 51.78 | 1621 | 45.24 | +++ |
| Collembola | 102 | 9.5 | 31 | 2.28 | 12 | 1.05 | 145 | 4.05 | +++ |
| Araneae | 16 | 1.49 | 67 | 4.93 | 24 | 2.09 | 107 | 2.99 | ++ ^② |
| Enchytraeidae | 75 | 6.96 | 3 | 0.22 | 10 | 0.87 | 88 | 2.46 | ++ |
| Coleoptera | 76 | 7.06 | 51 | 3.75 | 51 | 4.45 | 178 | 4.97 | ++ |
| Diplopoda | 43 | 3.99 | 10 | 0.74 | 23 | 2.01 | 76 | 2.12 | ++ |
| Hymenoptera | 96 | 8.91 | 102 | 7.51 | 98 | 8.54 | 296 | 8.26 | ++ |
| Isopoda | 14 | 1.30 | 57 | 4.19 | 13 | 1.13 | 84 | 2.34 | ++ |
| Diptera | 16 | 1.49 | 13 | 0.96 | 21 | 1.83 | 50 | 1.40 | ++ |
| Oligochaeta opisthopora | 11 | 1.02 | 29 | 2.13 | 11 | 0.96 | 51 | 1.42 | ++ |
| Diplura | 18 | 1.57 | 9 | 0.66 | 2 | 0.17 | 29 | 0.81 | + ^③ |
| Geophilomorpha | 9 | 0.64 | 18 | 1.32 | 5 | 0.44 | 32 | 0.89 | + |
| Scolopendromorpha | 2 | 0.19 | 3 | 0.22 | 2 | 0.17 | 7 | 0.20 | + |
| Lithobiomorpha | 2 | 0.19 | 7 | 0.52 | 1 | 0.09 | 10 | 0.28 | + |
| Pseudoscorpiones | 4 | 0.37 | 0 | 0 | 4 | 0.34 | 8 | 0.22 | + |
| Lepidoptera | 3 | 0.28 | 6 | 0.44 | 5 | 0.44 | 14 | 0.39 | + |
| Thysanoptera | 0 | 0 | 0 | 0 | 2 | 0.17 | 2 | 0.06 | + |
| Hemiptera | 7 | 0.65 | 16 | 1.18 | 4 | 0.34 | 27 | 0.75 | + |
| Homoptera | 3 | 0.28 | 6 | 0.44 | 8 | 0.70 | 17 | 0.47 | + |
| Symphyla | 3 | 0.28 | 0 | 0 | 2 | 0.17 | 5 | 0.14 | + |
| Blattoptera | 0 | 0 | 5 | 0.37 | 0 | 0 | 5 | 0.14 | + |
| Digononta | 0 | 0 | 14 | 1.03 | 8 | 0.70 | 22 | 0.61 | + |
| Eutardigrada | 1 | 0.09 | 6 | 0.44 | 2 | 0.17 | 9 | 0.25 | + |
| Psocoptera | 1 | 0.09 | 1 | 0.07 | 0 | 0 | 2 | 0.06 | + |
| Gastropoda | 0 | 0 | 1 | 0.07 | 0 | 0 | 1 | 0.03 | - ^④ |
| Σ (Sorts/Number) | 22/1077 | | 23/1359 | | 23/114 | | 26/3583 | | |
| H | 3.0362 | | 2.6489 | | 2.4479 | | | | |
| E | 0.6808 | | 0.5855 | | 0.5411 | | | | |
| C | 0.1777 | | 0.2914 | | 0.3204 | | | | |

Notes: Shannon-Wiener index (H) = $-\sum P_i \ln p_i$; Pielou evenness index (E) = $H/\ln S$; Simpson dominance index (C) = $(n/N)^2$

(In formula: $P_i = n_i/N$, n_i = Important value of every sort, N = Important value of total sorts, S = Number of sorts).

① Dominant groups(>10%); ② Common groups(1%–10%); ③ Rare groups (0.05%–1%); ④ Extreme rare groups(<0.05%)

Soil animal community of each forest in Confucian graveyard differ in composition, quantity indices and ecological distribution, which is closely related with their habitat condition, particularly species and quantity of forest plant in habitats. Secondary forests are the richest in tree species, shrub and grass, as compared with other two types of forests. Trees species are *Eucommia ulmoides* Olive, *Robinia pseudoacacia*, *Chinensis* Bunge, *Quercus acutissima* Carr, and *Broussonetia papyrifera* (L.) Vent, etc.. Canopy density is over 80%. The thickness of litter is 6.3 cm. For the *platycladus* forest the main tree species is *Platycladus orientalis* (Linn.), Franco. There are fewer deciduous broad-leaved plants such as *Quercus*

acutissima Carr, *Pistacia Chinensis* Bunge. The canopy density is about 65%. Shrub and grass under the trees are fewer than in Secondary forest. The thickness of litter is 2.6 cm. In *Quercus acutissima* forest, tall trees are only *Quercus acutissima* Carr and the canopy density is under 50%. Shrub and grass are scarce. The thickness of litter is 0.9 cm. Though the sort numbers of each forest soil animal community are nearly equal, individual numbers and sort composition differ greatly. The individual numbers are in order of *Platycladus* forest > *Quercus acutissima* forest > Secondary forest. As regards sort composition, the dominant groups in each forest habitat are the same and other sorts differ greatly. There

are 10 common groups in Secondary forest, 9 in *Platycladus* forest and 7 in *Quercus acutissima* forest. Moreover, these sorts and individual numbers are different in each forest. For example, *Enchytraeidae* and *Diplura* are common groups in Secondary forest, but they are rare groups in *Platycladus* and *Quercus acutissima* forests. *Blattoptera* and *Gastropoda* are only distributed in *Platycladus* forest, and *Thysanoptera* are only distributed over *Quercus acutissima* forest. From Table 1, we can see that *H* and *E* indices of soil animals in Secondary forest are the highest in the consequence of rich litter and humus organic matter in Secondary forest soil, and individuals of soil animal are more well-distributed in each sort. In *Platycladus* and *Quercus acutissima* forests, dominant plant and dominant soil animals are obvious for adapting with the former. Therefore, in these three forests, *C* index of soil animals is in order of *Quercus acutissima* forest > *Platycladus* forest > Secondary forest.

In soil layers of each forest, sort numbers and individual numbers of the soil animal community are different. There exists differentiation in vertical direction. Fig.1 shows the vertical changes of each forest soil animal community in soil layers. The general change tendency is similar. For example, the surface soil layer has the most sorts and individual numbers with a successive decrease in each deeper layer. So the feature of forest soil animal congregating to surface horizon is very obvious in Confucian graveyard, and the feature is more obvious in sort number than in individual number, and *Platycladus* and *Quercus acutissima* forests than in Secondary forest.

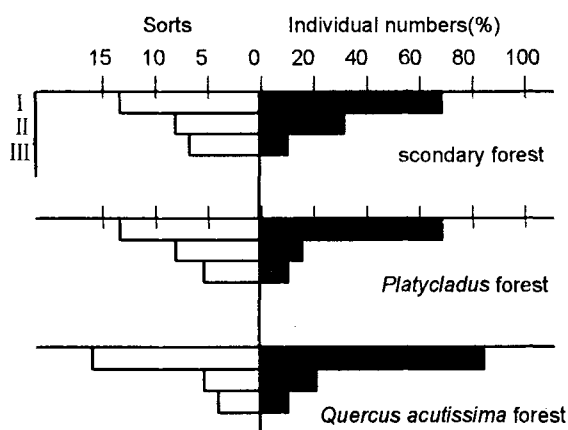


Fig. 1. The distribution of mid-small sized soil animals in different soil layers of three forest

26 sorts of soil animal were all collected in three forests in Confucian graveyard, among them, 19 sorts are common ones which are possessed by three forests. According to resemblance index formula of Sørensen: $S = 2C/A+B$, *A* = Number of sorts in *A*

habitat, *B* = Number of sorts in *B* habitat, *C* = Number of common sorts in *A* and *B* habitat), resemblance index of three forest soil animal communities are calculated. The resemblance index between Secondary forest and *Platycladus* forest is 0.8889, The resemblance index between *Quercus acutissima* forest and *Platycladus* forest is 0.8696, The resemblance index between Secondary forest and *Quercus acutissima* forest is 0.9333. The results show that these resemblance are very high, they are extreme similar (extreme similar: 1.00-0.75, moderate similar: 0.75-0.50, moderate not similar: 0.50-0.25, extreme not similar: 0.25-0.00) (Watanabe 1977). Among them, the resemblance of soil animals in Secondary forest with that in *Quercus acutissima* forest is the highest. So high resemblance explain that three forest soil animal communities in Confucian graveyard are closely related to each other in formation and development due to near spatial distance and the influence of human in long time.

Conclusion

3583 forest soil animals were collected in Confucian graveyard of Qufu. They belong to 5 Phylums, 11 Classes 23 Orders. 2 sorts are dominant and 9 sorts are common. Sort composition and individual numbers of soil animal community in each forest habitat are different. *H* and *E* indices are Secondary forest > *Platycladus* forest > *Quercus acutissima* forest, *C* index is just the contrary.

Most sort numbers and individual numbers of forest soil animal communities in Confucian graveyard of Qufu are distributed in surface soil layer, their congregating to surface horizon are obvious.

The resemblance indices of three forest soil animal communities are all extreme similar.

References

- Zhang Rongzu. 1980. Study dynamic on soil animals in ecological system in foreign countries. *Ecological System Research*, 1:257-264
- Cui Zhendong. 1985. Actions of soil animals. *Journal of Zoology*, 2:48-52
- Yin Wenying *et al.* 1992. Soil animals in subtropical zone of China. Beijing: Science Press, 576 p
- Zhang Zhenhua. 1993. Soil animals. Hangzhou: Hangzhou University Publishing House, 256 p
- Zhong Juemin. 1985. Pictorial handbook of insect classification. Nanjing: Jiangsu Science and Technology Press, 318 p
- Jin Jieliu. 1985. Morphological classification of insect. Shanghai: Fudan University Press
- Watanabe, H., Kamihira, Y 1977 *et al.* Soil Animal Community. JIBP SYNTHESIS, TOKYO:15: 81-124.